USEPA Office of Research and Development
CENTER FOR ENVIRONMENTAL SOLUTIONS AND EMERGENCY RESPONSE

Fentanyl Contaminated Properties
How would we clean them up?

Lukas Oudejans, Ph.D

National Environmental Health Association Webinar
December 3, 2020

Outline

- EPA and Emergency Responses
  - Role of EPA's Homeland Security Research Program
- Problem Definition
  - Background on Fentanyl
  - EPA's Fentanyl Fact Sheet
  - Voluntary Guidelines for Meth Lab Cleanup
- Research Gap Identification
  - Sampling and Analysis
  - Decontamination Options for Interior Spaces
  - Decontamination Options for (First) Responder Gear
- Practical Approaches
  - Lessons Learned

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EPA's Role in Emergency Response

Assist water utilities in protecting their systems and responding to contamination incidents

Respond to environmental contamination incidents

Regulate pollutant discharge into waters

Register antimicrobials

Control hazardous wastes from cradle to grave

Lead the protection of water infrastructure

Conduct biological and chemical agent cleanup

Develop capable laboratory network and surveillance/monitoring systems

Homeland Security Research Program

Vision

Federal, state, tribal, and local decision makers have timely access to information and the tools they need to ensure community resilience to catastrophes involving environmental contamination that threatens public health and welfare.

Program Objectives

Advance EPA's capabilities and those of our state, tribal, and local partners to respond to and recover from wide-area contamination incidents

Improve the ability of water utilities to prevent, prepare for, respond to and recover from water contamination incidents that threaten public health

RESPONSE MISSION SUPPORT

How do we contain the spread of the contaminant?

How do we characterize the contaminated area to inform public health decisions?

What capabilities do we have to clean-up contaminated areas?

How do we manage waste, both during response and long-term?

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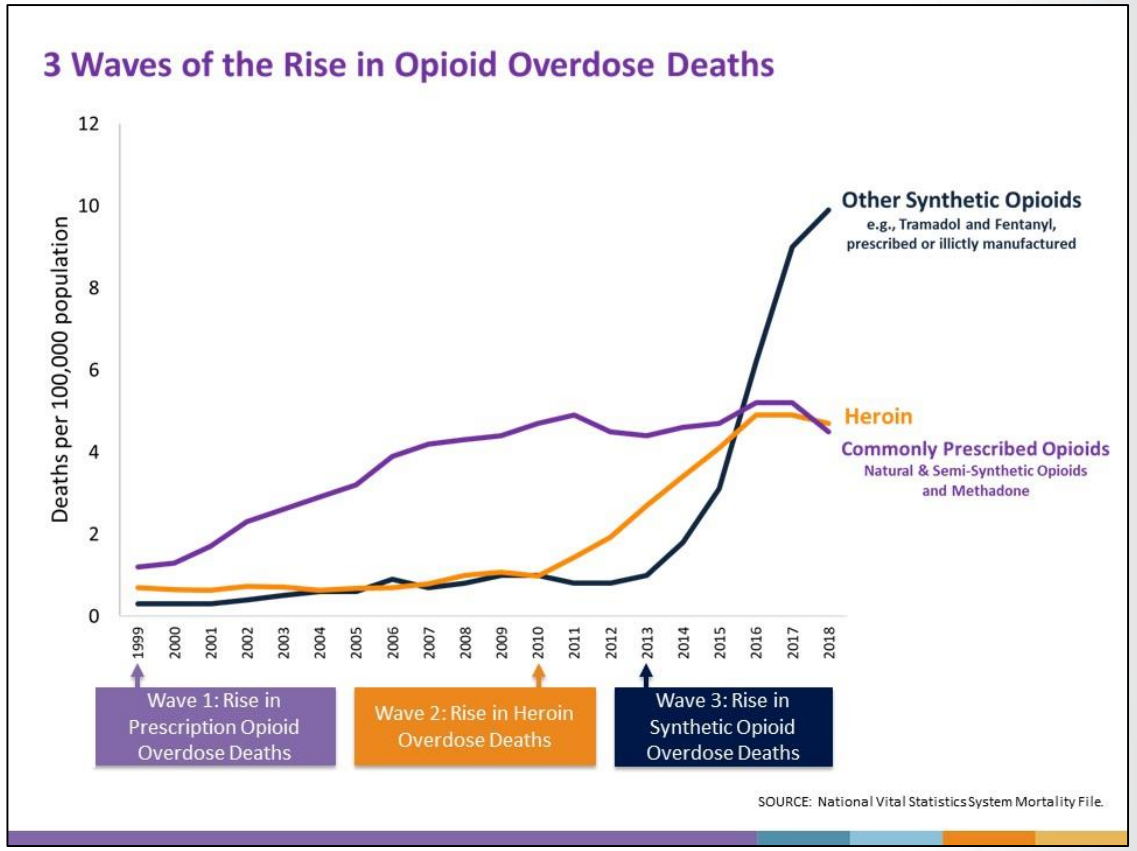
Opioid Crisis: Problem Definition

- Declared Nationwide Public Health Emergency (White House October 26, 2017)
- Rise in overdose deaths is largely due to the proliferation of illicitly manufactured fentanyl, a highly potent synthetic opioid, and fentanyl analogs
- 2018: >67,000 drug overdose deaths in USA; >31,000 deaths were associated with synthetic opioids (other than methadone)
- Shift to Western US (NPR Nov 17, 2020)



NATIONAL

Street Fentanyl Surges In Western U.S., Leading To Thousands Of Deaths

November 17, 2020 · 5:00 AM ET

Heard on All Things Considered

Opioid Crisis: Problem Definition

- Fentanyl and fentanyl analogs are a class of synthetic opiates (opioids)
  - Scheduled substances under the Controlled Substance Act
- Most fentanyl powders are imported from China & Mexico
- Fentanyl analogs are ever changing

$5M in drugs seized during Delaware's largest fentanyl bust
September 22, 2020... "Among the drugs **seized** was enough **fentanyl** to kill 750,000 people"

"Enough fentanyl to kill 2 million people seized in NY home", DEA says [March 2, 2019]

CBP Officers Seize Largest Amount of Fentanyl in CBP History

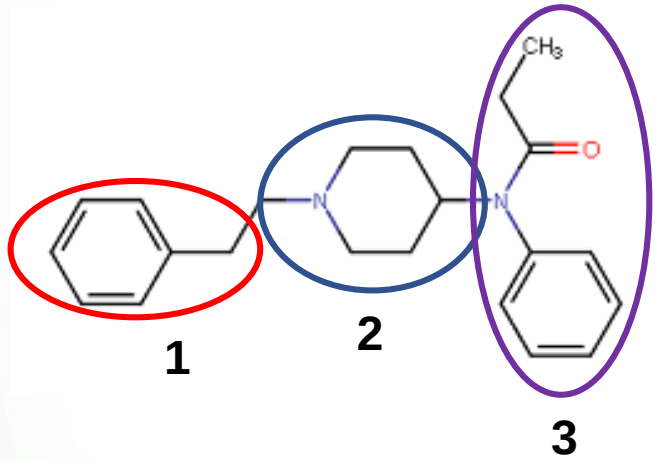
www.cbp.gov, January 31, 2019
Press Event at the Port of Nogales, AZ

Potential Scenario

- Law enforcement and Hazmat teams have sought EPA technical support in advising proper PPE and decon approaches at contaminated sites
- Calls about:
  - ✓Mixing houses, pill factories
  - ✓Makeshift laboratories found in apartments, hotels, houses, garages and storage facilities
  - ✓Illegal dumps containing the remnants of laboratories
- Calls about possible fentanyl release in prisons
- *No EPA responders have responded on site, as of yet*

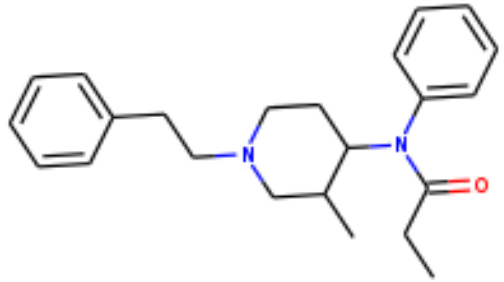
Background on Fentanyl

- Fentanyl analogs typically can be produced by altering the propyl alkyl amide moiety
- Modification is possible at all 3 parts of the molecule resulting in an infinite number of potential analogs.

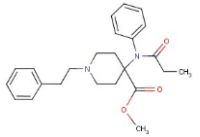


Fentanyl

1. Phenyl alkyl moiety
2. Piperdinyl ring moiety
3. Propyl alkyl amide moiety



3-methyl fentanyl



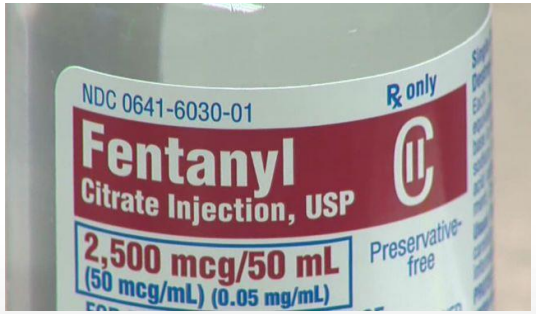
Carfentanil

Occupational Exposure Scenarios

Potential exposure (without proper PPE) from

- Inhalation
- Oral (ingestion)
- Dermal
  - Larger amounts only
  - Route to mucous membrane
- Percutaneous
  - Accidental injection

Lethal doses of heroin (left, 30 mg) and fentanyl (right, 3 mg) By New Hampshire State Police Forensic Lab/Public domain



Initial EPA Effort:

Development of **Fentanyl Fact Sheet**

- Provide EPA On Scene Coordinators (OSCs) with technical information

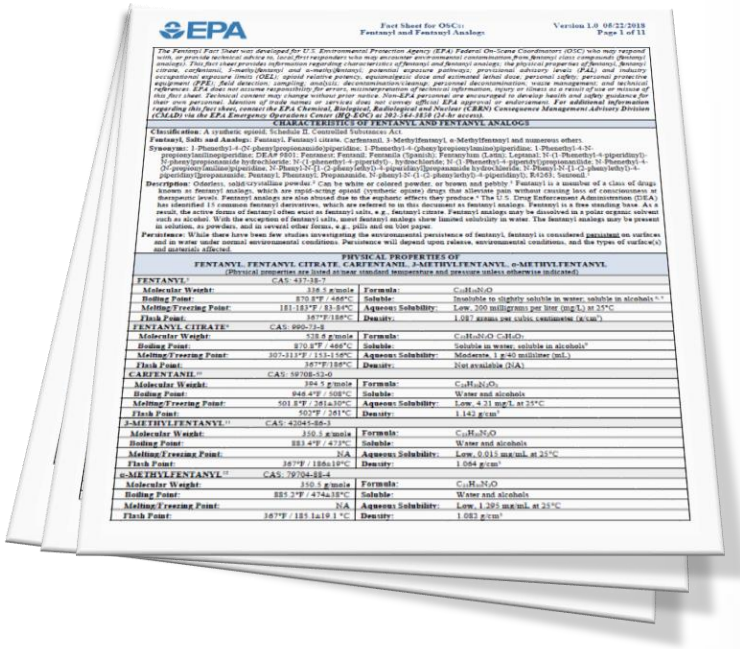
- To get ahead of the curve on possible EPA involvement in the cleanup and remediation

- To provide local state and county Hazmat partners with the most pertinent information needed for a safe response at opioid contaminated sites

Initial EPA Effort:

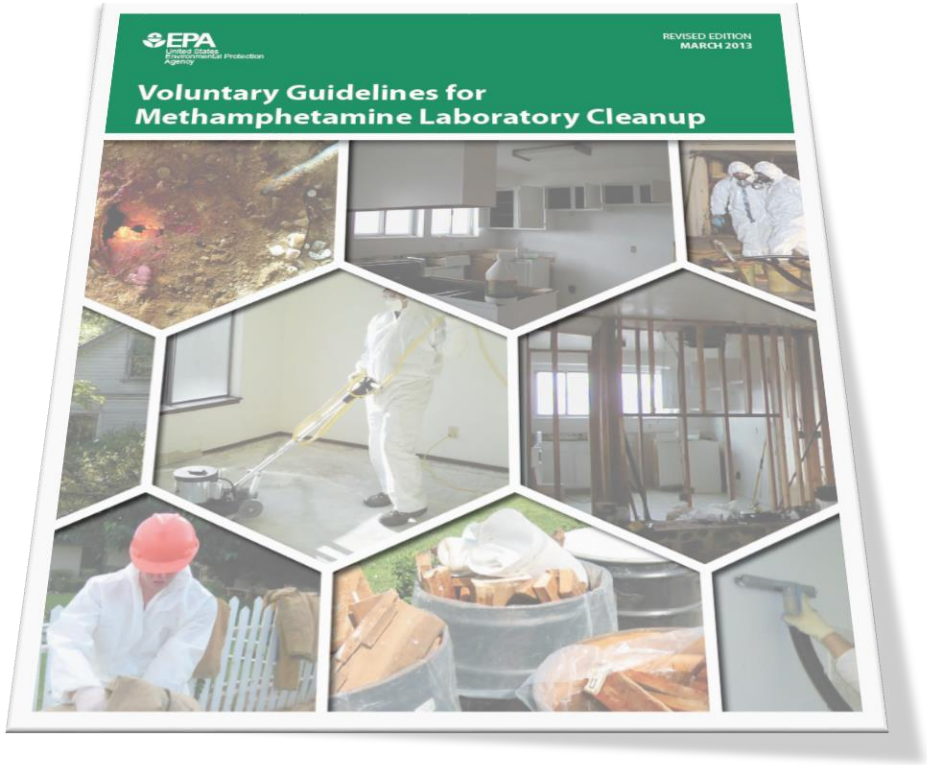
Fentanyl Fact Sheet (May 2018)

- It is a Fact Sheet, not "guidance" – no statutory/regulatory authority
- https://www.epa.gov/emergency-response/fact-sheet-fentanyl-and-fentanyl-analogs
- Living document



EPA's Voluntary Guidelines for Methamphetamine Laboratory Cleanup

- A 2020/2021 update to this document will include information related to clandestine fentanyl laboratory cleanup *[in progress]*



www.epa.gov/emergency-response/voluntary-guidelines-methamphetamine-laboratory-cleanup

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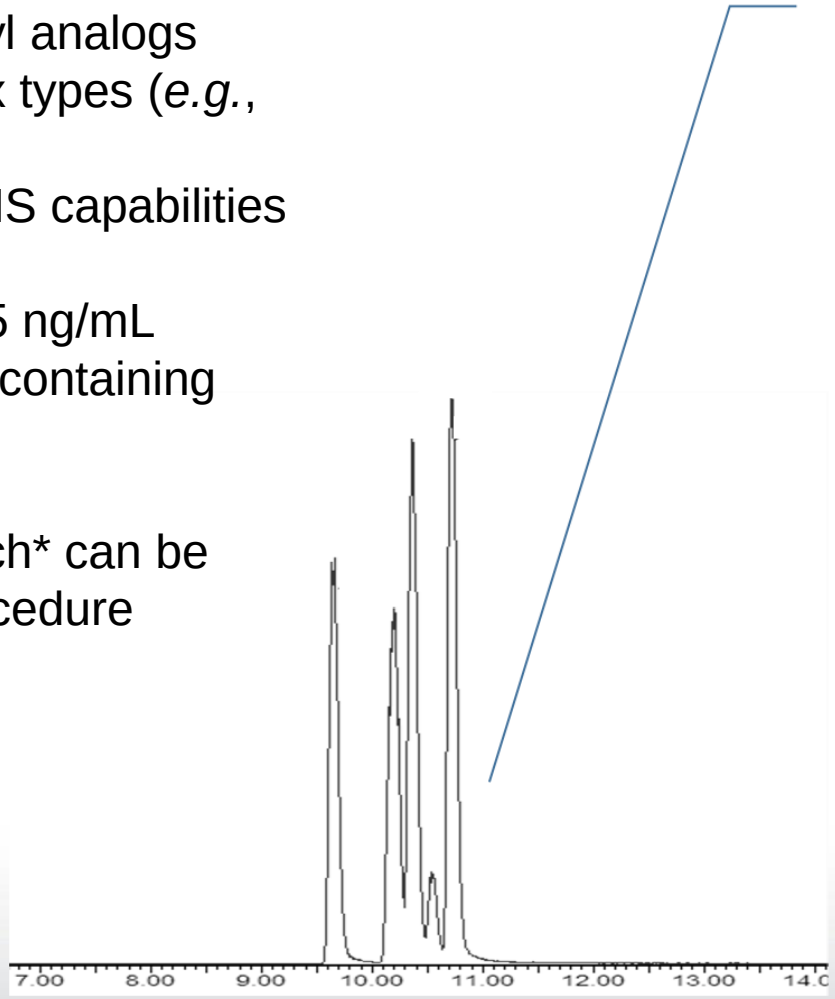
Identified Gaps / Lack of Information

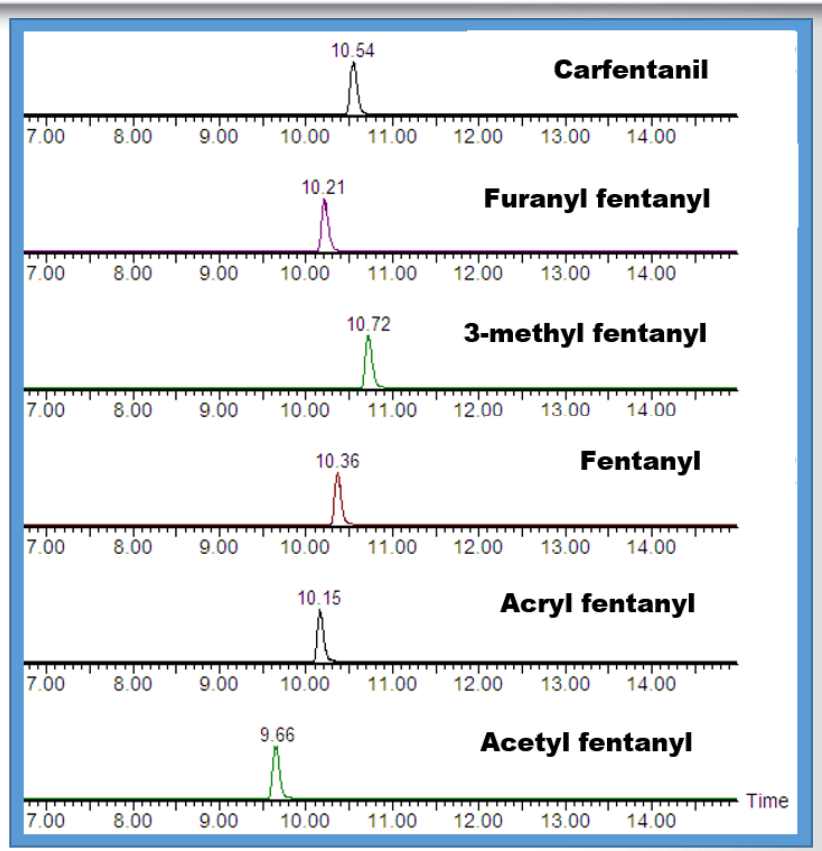
- Sampling and Analysis
  - *Lack of environmental sampling & analytical methods*
- Decontamination
  - *No operationally relevant information available*
- Toxicology
  - *No info on environmental exposure (vs clinical exposure)*
  - *No dermal exposure values*
- PPE
  - *Selection of PPE was complicated leading to inconsistencies*
    - Inhalation protection always needed
    - Dermal protection may drive PPE selection

Research Supporting Fentanyl Site Cleanup

Method Development & Optimization

- Investigation of fentanyl and fentanyl analogs of interest with environmental matrix types (*e.g.*, water, surfaces)
    - LC-MS/MS and UPLC-MS/MS capabilities
- Sensitive and robust capability (0.05 ng/mL range) with methanol/water eluents containing an acidic modifier
- Previous pesticide sampling research* can be used to optimize wipe sampling procedure





*S.A. Willison et al., *Science of the Total Environment*, 655 (2019) 539.

Optimization of Sampling and Analysis

Fentanyl Compounds:

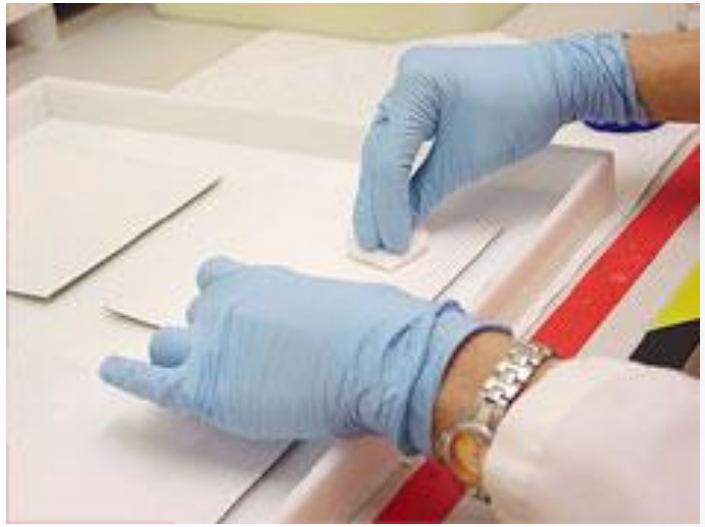
- Carfentanil
- Furanyl Fentanyl
- 3-methyl Fentanyl
- Fentanyl
- Acryl Fentanyl
- Acetyl Fentanyl

- Isotopically-labeled (IS)
  - Carfentanil-D_5
  - Fentanyl-D_5
  - Acetyl Fentanyl-$^{13}C_6$

- Evaluate analytical methods for environmental samples
  - LC-MS/MS capabilities
- Evaluation of solvents
  - Elution system
  - Flow rates
  - Wipe wetting solvents
- Evaluate sampling
  - Surfaces
  - Water

Preliminary Wipe Sampling Method Development and Evaluation

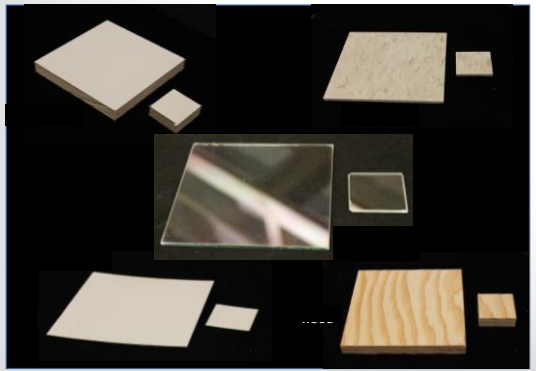
- Metal surface spiked with fentanyl analogs
  - 0.2 ng/cm^2 surface concentration†
- Previous pesticide sampling research* can be used to optimize wipe sampling procedure
  - Two wipes for each 100 cm^2 coupon
    - Horizontal Z-pattern, then around perimeter
    - Vertical Z-pattern, then around perimeter
- Wetting solvent may affect recovery results
  - **MeOH > IPA > 90:10 H_2O/ACN**



† E. Sisco, M. Najarro, A Burns, *Forensic Chemistry*, 11 (2018) 47.
*S.A. Willison et al., *Science of the Total Environment*, 655 (2019) 539.

Preliminary Surface Wipe Evaluation

- Surface spiked with fentanyl analogs
  - 0.2 ng/cm^2 surface concentration
- Two wipes for each 100 cm^2 coupon
  - Horizontal Z-pattern, then around perimeter
  - Vertical Z-pattern, then around perimeter
- Placed in VOA vial, added internal standard, 10 mL of extraction solvent, sonicated for 10 minutes, filtered, and analyzed



Surface	Metal		Laminate	
Analyte	Avg* % Recovery	% RSD	Avg* % Recovery	% RSD
Carfentanil	116	17	81	16
Furanyl fentanyl	64	10	73	5
3-methyl fentanyl	72	8	79	4
Fentanyl	120	9	93	7
Acryl fentanyl	64	12	71	6
Acetyl fentanyl	117	10	99	8

*Average of 8 samples

Sampling & Analysis Conclusions

Sampling:

- Methanol wetted wipes work well for surface sampling of fentanyl and fentanyl analogs from nonporous materials

Analysis:

- Flow rates and elution solvents may affect sensitivity

On-going research efforts include:

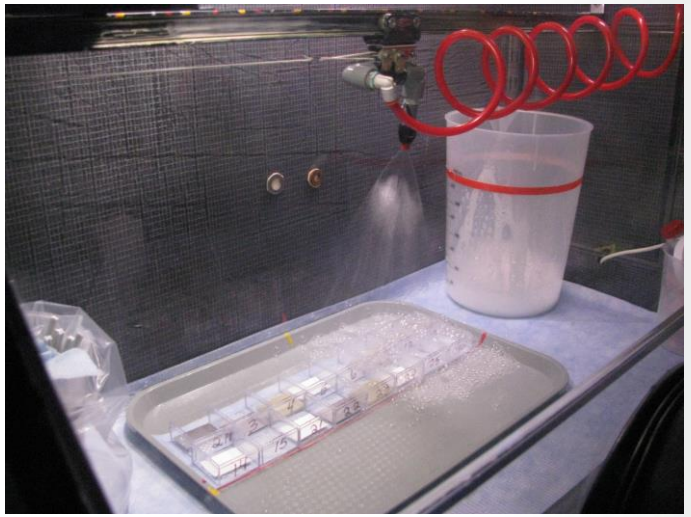
- Alternative wipe materials (e.g., pre-packaged, pre-wetted wipes) and their effects on recovery
- Alternative surfaces of interest (e.g., household surfaces)
- Alternative matrix types (e.g., water contamination)

Decontamination / Cleanup

- Scientific data for fentanyl/opioid environmental cleanup are lacking
- Scientific data were limited to basic reaction chemistries
- Cleanup responses appear to rely strongly on the physical removal of fentanyl (instead of degradation of fentanyl)
  - Creates fentanyl/opioid containing waste

EPA-HSRP Surface Decon Research

- Decontamination of building materials contaminated with fentanyl-HCl powder
- Bench-scale study, yet realistic scenario
  - Various decontaminants / active ingredients
  - Representative decon solution amounts
  - Relevant building materials
  - Impact of benign additives on efficacy



Spray application setup – EPA/Battelle

peracetic acid

Dahlgren Decon
EasyDecon DF200

hydrogen peroxide

Meth Remover
ZEP 4% HP

percarbonate

OxiClean

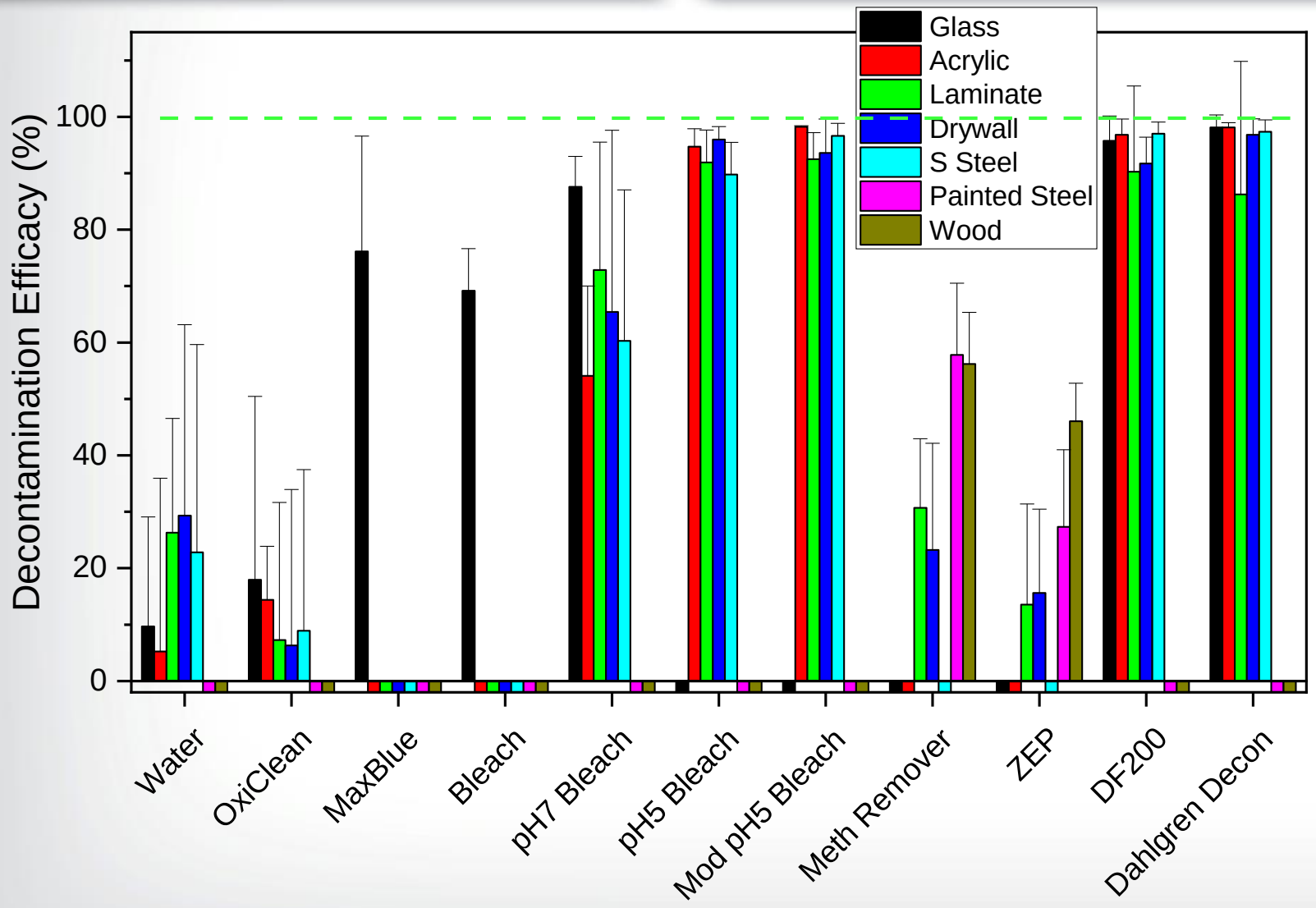
hypochlorite

Bleach
with mods

*trichlor**

MaxBlue

Decon Efficacy Results (1 hr contact time)

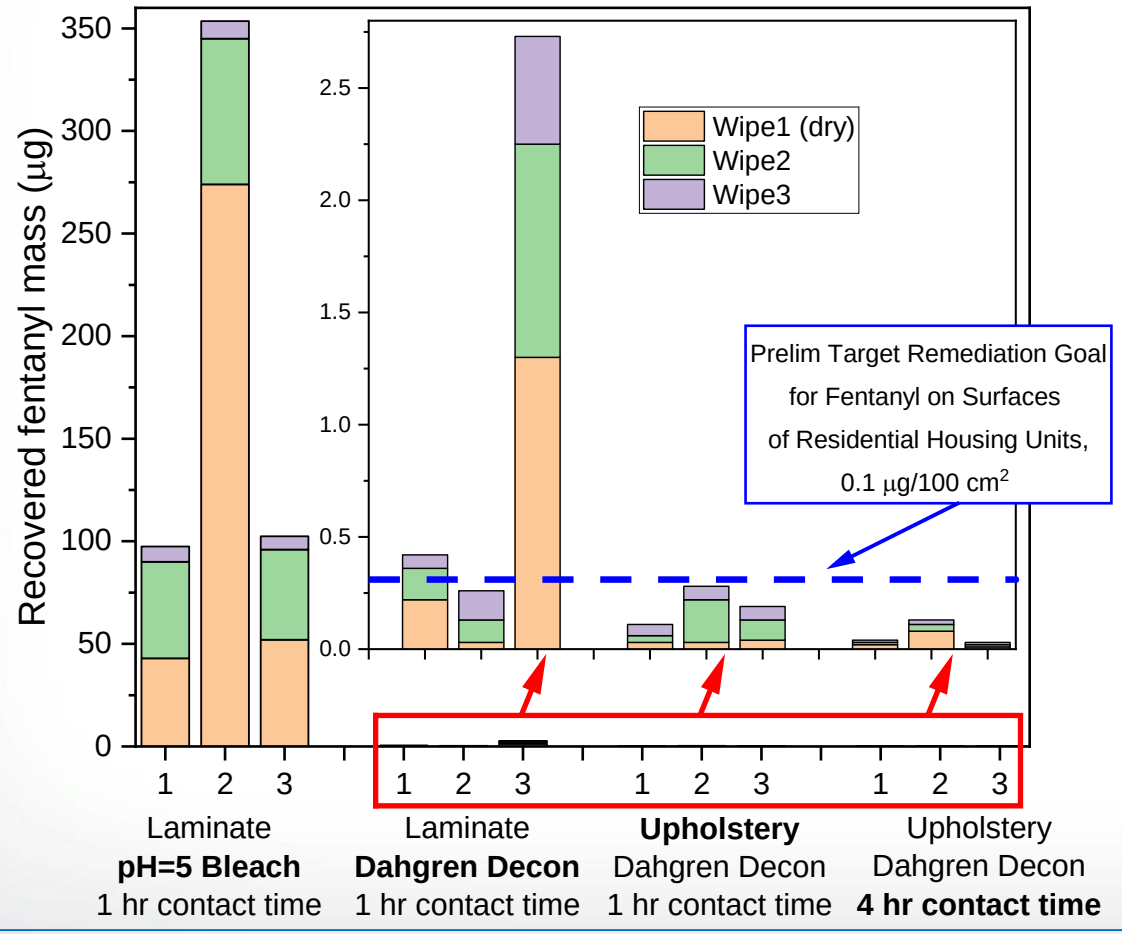


*:Not all material/decontaminant combinations were considered

- Water and OxiClean show no degradation capabilities
- Minimal material dependence in decontamination efficacy for these relatively nonporous materials
- Highest efficacies observed for Dahlgren Decon, EasyDecon DF200, and pH5 bleach
- All products prepared as per manufacturer or label descriptions
- [Not shown] Some formulations may impact efficacy (e.g., ascorbic acid)
- Occasional “clumping” of fentanyl powder was observed

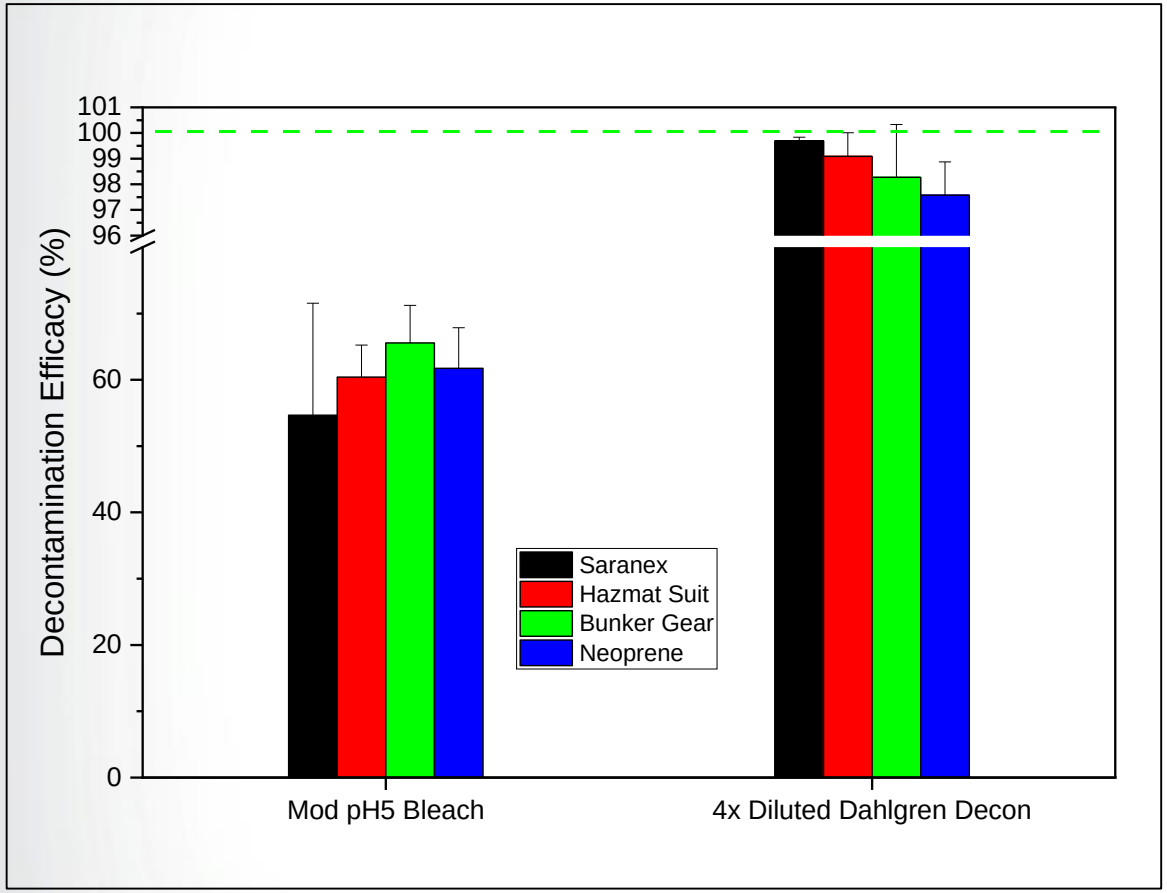
How Clean is Clean?
Medium-size Coupon Decon Tests

Residual fentanyl on surface post-decontamination



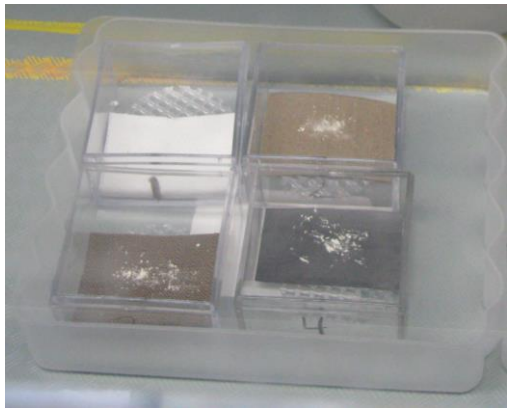
- Residual fentanyl may be below preliminary remediation goal for fentanyl (adjusted for sampled surface size)
- This is based on bench-scale research
  - Ideal conditions
  - No additives present
- Occasionally observed “clumps” of fentanyl (aggregated in decon solution) may result in higher recoveries (see laminate replicate #3)

Decon Efficacy Results - Decon Line (*5 min*)



After a 5 min contact time:

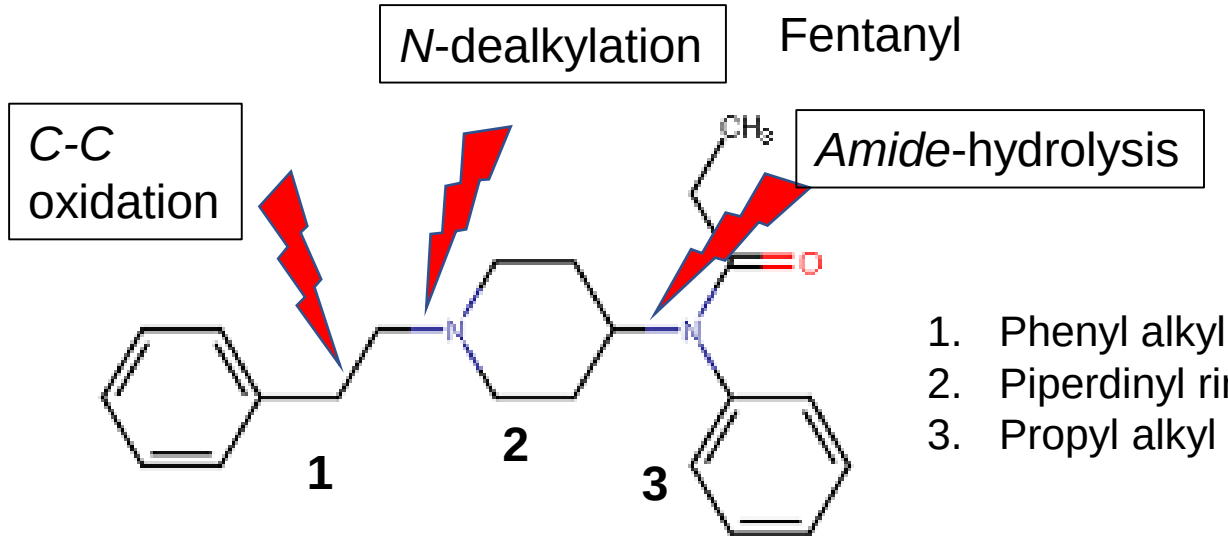
- ❑ Approximately 60% reduction of fentanyl on surfaces using pH5 bleach with surfactant (“Mod pH5 Bleach”)
- ❑ Better than 98% efficacy when using 4x diluted Dahlgren Decon (n=3)



Top Left: Saranex (Tyvek suit)
Top Right: Hazmat Suit (DuraChem® 500 garment)
Bottom Left: Bunker Gear (Firefighter turnout gear)
Bottom Right: Neoprene (glove material)

Degradation of Fentanyl: By-products

- Fentanyl degradation is complex and expected to be depending on pH of decon solution
- Fentanyl analog degradation may be different from fentanyl itself



1. Phenyl alkyl moiety
2. Piperdinyl ring moiety
3. Propyl alkyl amide moiety

- Fentanyl by-products could be numerous
- Each (stable) by-product could carry toxicity
  - it is imperative that by-products are less toxic than original product

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Practical Approaches / Lessons Learned

- Cleanup solutions that degrade fentanyl on materials are available
- Low-cost COTS approaches (like bleach) are only effective after acidification and addition of surfactants
- Cleanup approaches still need to be assessed
  - Physical removal needs to be thorough
    - Would be slow and generates fentanyl containing waste
  - Chemical degradation needs to overcome material demand
    - Need verification of (lack of) toxic byproduct formation
  - Hybrid of physical removal and chemical degradation appears to be the most efficient approach
- Observed clumping of undissolved fentanyl powder requires attention

Next Steps

- More decontamination research is required to consider:
  - Formation of (stable) and toxic by-products during decon
  - Impact of other chemicals on efficacy
  - How to decon porous materials
  - Other fentanyl analogs

Acknowledgments / Points of Contact

EPA, Fentanyl Fact Sheet:

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Lukas Oudejans/EPA/ORD/CESER

EPA, Fentanyl Research Partners:

EPA Regions 1, 3, 4, 5, and 8

Michigan DHHS, Massachusetts DEQ

EPA, ORD/CESER:

Stuart Willison, Matthew Magnuson, Lukas Oudejans, and John Lipscomb (retired)

Website: https://www.epa.gov/homeland-security-research